

# **"Hip Fracture Surgery: Perioperative Outcomes Across Different Anesthesia Techniques - A Systematic Review"**

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**Running Title:** Perioperative Outcomes of Anaesthesia in Hip Fracture Surgery

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## **Abstract:**

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) can benefit from various regional anesthesia (RA) techniques that enhance patient outcomes. Our study aimed to determine if RA reduces mortality, cardiovascular morbidity, deep venous thrombosis (DVT), pulmonary embolism (PE), blood loss, surgery duration, pain, opioid-related side effects, cognitive defects, and hospital stays while improving rehabilitation. A systematic review of randomized controlled trials (RCTs) from 2000 onward compared RA to general anesthesia (GA) and evaluated systemic versus regional analgesia. The evidence from RCTs did not conclusively show that anesthesia type impacts mortality, cardiovascular issues, or DVT and PE incidence with thromboprophylaxis. However, RA may reduce blood loss. Our findings emphasized the importance of individualized analgesic approaches, such as fascia iliaca compartment block (FICB), intrathecal morphine (ITM), local infiltration analgesia (LIA), pericapsular nerve group (PENG) block, lumbar plexus block, and erector spinae plane block (ESPB), to optimize pain management and minimize opioid use, highlighting a need for balanced risk-benefit strategies to improve recovery. Surgery duration showed no significant difference between RA and GA. Regional analgesia was more effective in reducing postoperative pain, morphine use, and nausea and vomiting compared to systemic analgesia. Despite these benefits, hospital stay length and rehabilitation outcomes were not significantly influenced by RA or analgesia methods for THA and TKA.

**Keywords:** Systematic review; Total hip arthroplasty; Total knee arthroplasty; Regional and general anaesthesia

## **Introduction**

Many regional anaesthesia (RA) procedures can be used to perform total hip arthroplasty (THA). By using peripheral nerve blockade (PNB), one can reduce pain in the operated limb specifically while avoiding some of the unintended side effects of central nerve blockade (CNB). <sup>(1)</sup> Because continuous PNB offers longer postoperative pain treatment than single-injection methods, its use has expanded. RA has several disadvantages despite its low risk of problems and apparent advantages in some orthopedic surgeries, like better postoperative pain treatment, rehabilitation, and shorter hospital stays. <sup>(2)</sup> Even for skilled practitioners, block operations have an inherent failure rate. Two criticisms of RA are operating theatre delays and the disadvantage of increased liability. Additional constraints include the cost of ultrasound apparatus, which is expected to rise in prominence as a nerve localization technique, and training to acquire the technical skills necessary for effective RA. <sup>(3)</sup> Many people have misunderstandings and anxieties regarding RA. Despite the growing utilization of these techniques, large meta-analyses and randomized controlled trials (RCTs) that compare regional anesthesia (RA) and general anesthesia (GA) for major lower limb orthopedic surgery frequently yield contradictory results. <sup>(4)</sup> It is noteworthy that the findings of meta-analyses often diverge from those of significant RCTs. Drugs utilized in landmark studies contrasting GA and RA for hip surgery are no longer available. Surgical procedures and patient care following surgery have greatly advanced within the last 20 years. <sup>(5)</sup> Because of improved needle technology, block insertion methods, catheter design, and infusion pumps, RA has advanced, and new thromboembolic prophylaxis regimens have been established. To resolve these concerns, we have examined current data for applicability and relevance to contemporary anesthesia practice. To determine if RA or regional analgesia was better than GA or systemic analgesia for

total hip replacement, we systematically evaluated the literature published after 2007. <sup>(6)</sup> Our review sought to provide specific answers on the effects of RA or regional analgesia on mortality, cardiovascular morbidity, pulmonary embolism (PE), deep venous thrombosis (DVT), length of stay, pain, and adverse effects associated with opioids. Furthermore, investigated whether localized analgesia or RA enhanced recovery.

## **Methods**

### **Database Search Strategy**

A thorough search was conducted across databases like Embase, Science Direct, PubMed, Scopus, and Web of science to identify studies comparing "total hip replacement" OR "THA." 'Anaesthesia' or 'analgesia' were combined with these search results using the Boolean search operator.

### **Eligibility Criteria**

This study analyzed case studies, cross-sectional studies, and prevalence studies from 2014 to 2023, focusing on the comparison of GA with regional anaesthesia for surgery. The research included both localized and systemic approaches to postoperative analgesia. Exclusion criteria included joint arthroplasty, merged hip and knee arthroplasty, or failure to provide distinct information about knee surgery patients. Clinical trials using analgesics, not freely available in full text, focused on musculoskeletal disorders, duplicate records, or neuraxial approaches limited to opioids were also excluded. The dataset used for comparison included year of publication, authorship, patient number, mean age, male-to-female ratio, and co-morbidities. Specific results were sought in each article, including cardiovascular morbidity, DVT, PE, duration of surgery, pain, adverse effects of opioids, cognitive impairments, length of stay, and rehabilitation. Primary or secondary results were ascertained.

### **Data Synthesis and Quality Assessment**

The study screening process involved reviewing study titles and abstracts, assessing eligibility, and resolving disagreements. Qualitative assessments were conducted on outcomes for each intervention and comparison. Criteria such as authors, publication year, study design, sample size, participant ages, co-morbidity, intervention, and length of stay were used. The AXIS tool, introduced in 2016, was used to evaluate study design, reporting quality, and bias risk in cross-sectional studies. All articles were assessed for eligibility and methodological quality using 20 items covering objectives, methodology, results, and outcomes.

### **Sample size**

A total of 175 documents were identified through database searches. After removing duplicates, 100 documents remained. 89 full-text articles were excluded for various reasons, including wrong study design or comparator, being a letter to the editor, lack of full text, or being non-English. Ultimately, 11 articles were included in the review (figure 1).

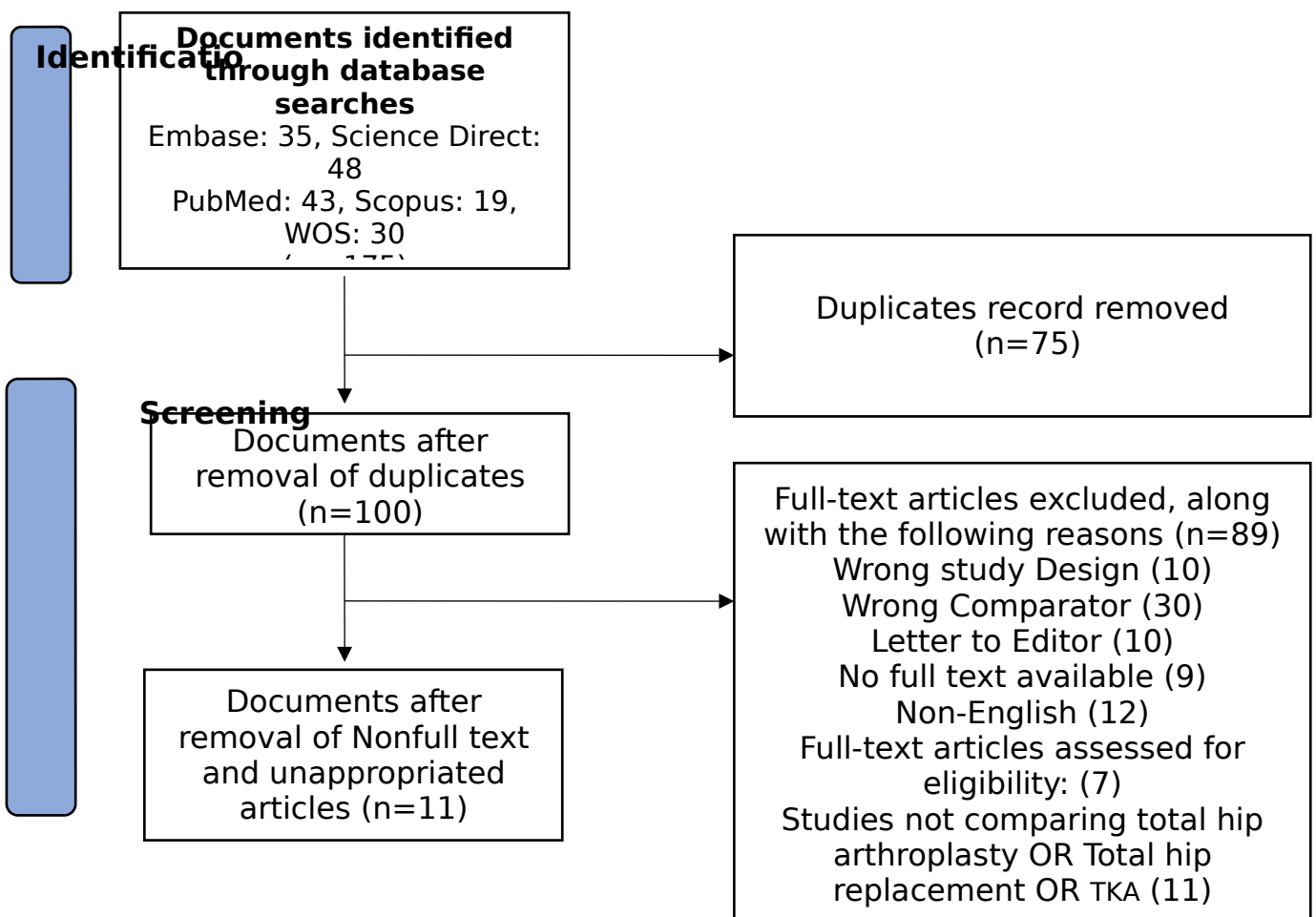
### **Statistical Analysis**

A descriptive synthesis of the extracted data from various selected studies is presented. This study considered a weighting procedure for the clinical effectiveness of the included studies of comparing RA with GA and assessing systemic versus regional analgesia only when the procedure for combining data from multiple studies was satisfied. Because of the low or negligible prevalence of mortality in each study, the continuous outcomes measures were computed and expressed as a weighted mean difference with 95% confidence intervals. To summarise the findings across the studies, a statistical significance of p was also considered.

### Assessment of risk of bias

One investigator initially screened the articles according to the inclusion and exclusion criteria, followed by a second investigator conducting a subsequent review. Discrepancies were resolved through a consensus method, and a third review author was consulted if disagreements persisted. If the authors could not be reached or the information was unavailable, the criterion was marked as 'unclear'. The Cochrane risk of bias tool from the 'Cochrane Handbook for Systematic Reviews of Interventions' was used to evaluate the risk of bias, with each criterion rated as 'low risk', 'high risk', or 'unclear'.

### Identification of studies via databases and registers



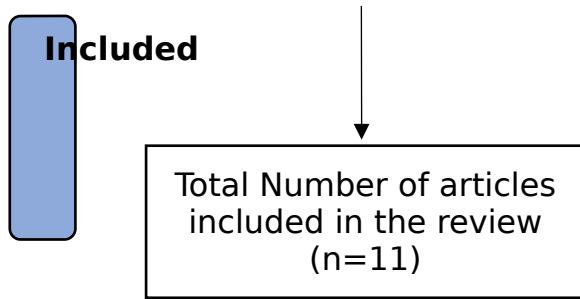


Figure 1- Flow chart

## Results

**Table 1:** Comparison of Total number of subjects, Mean patient age, Percent male/ female, and Co-morbidity

Study	Total number of subjects	Mean patient age	Percent male/ female	Co-morbidity
<b>Gola et al.<sup>(7)</sup></b>	109 subjects	The mean patient age in the study was 65 years.	The percentage of females was Controls-28 FICB-29	The comorbidities included hypertension, overweight, ischaemic heart disease, and diabetes, among others.
<b>Kuchalik et al.<sup>(8)</sup></b>	80 patients	Group ITM- 66 (51-84) Group LIA- 67 (50-85)	The percentage of females was 41% (16 out of 39), and the percentage of males was 59% (23 out of 39).	NR
<b>Pascarella et al.<sup>(9)</sup></b>	60 patients	PENG - 66.4 (12.4) Control- 66.7 (8.6)	In the study, 57% of the male and 43% of the female participants underwent THA.	The study included adults undergoing primary hip arthroplasty with ASA physical status 1-3. Patients with ASA physical status 4 or more, dementia, or cognitive impairment were excluded from the study.
<b>Stevens et al.<sup>(10)</sup></b>	59 patients	The mean patient age in the study was 66	The study included 50% male and 50% female	NR

		years, with similar preoperative characteristics between the plexus and control groups	patients, with no significant gender-based differences in preoperative characteristics	
<b>Lennon et al.</b> <sup>(11)</sup>	64 patients.	Saline-67 years Ropivacaine-65 years	The percentage of females was 71% in the Ropivacaine group and 74% in the Saline group	NR
<b>Townsend et al.</b> <sup>(12)</sup>	88 patients.	The patients included in the study were between 18 and 80 years old.	In the ESPB group, the percentage of males was 17.5%, and the percentage of females was 33.3%.  In the control group, the percentage of males was 15.9%, and the percentage of females was 33.3%.	The comorbidities reported were diabetes, osteoporosis, sciatica, and herniated disc
<b>Hanychet al.</b> <sup>(13)</sup>	23 patients	The mean age of the patients in the study was 63.9 years	A total of 23 participants were recruited, with 12 in the epidural group and 11 in the ESPB group.	NR
<b>Flaviano et al.</b> <sup>(14)</sup>	64 patients	FIB group: 71.4 ± 10.1 ESPB group: 69.3 ± 12	FIB group (F)-20  ESPB group(F)-12	NR
<b>Becchi et al.</b> <sup>(15)</sup>	73 patients	The mean patient age in Group A was 69 years (range: 61-77) and in Group B was 71 years (range: 60-82).	The study documented 16 males and 19 females	NR
<b>Andersen et al.</b> <sup>(16)</sup>	888 (TKA patients) and 756 (THA patients )	NR	NR	NR
<b>Turnbull et al.</b> <sup>(17)</sup>	16 patient	The mean age was 69	NR	NR

		to 65 years		
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FICB- Fascia iliaca compartment block; ITM- intrathecal morphine; LIA- local infiltration analgesia; PENG- Pericapsular nerve group; FIB- Fascia iliaca block; LOS- length of hospital stay; ESPB- Erector Spinae plane block; TKA- Total knee arthroplasty; THA - Total hip arthroplasty; NRS- Numeric rating scale; NR- Not reported

## Patients and Age

A study involving 109 subjects with a mean patient age of 65 comprised two groups: 28 controls and 29 FICB patients, all females. Another study examined 80 patients divided into two groups, ITM and LIA, with mean ages of 66 (ranging from 51 to 84) and 67 (ranging from 50 to 85), respectively. The female percentage was 41% (16 out of 39), while males accounted for 59% (23 out of 39). In a study of 60 patients undergoing THA, the mean ages were 66.4 (12.4) in the PENG group and 66.7 (8.6) in the control group, comprising 57% males and 43% females. Another study examined 59 patients with a mean age of 66 years, equally divided by gender, with 50% males and 50% females, showing no significant preoperative differences. Research involving 64 patients reported mean ages of 67 years in the saline group and 65 years in the ropivacaine group. The female percentage was 71% in the ropivacaine group and 74% in the saline group. A study included 88 patients aged 18 and 80. In the ESPB group, males constituted 17.5% and females 33.3%, while the control group had 15.9% males and 33.3% females. Another study involved 23 patients with a mean age of 63.9 years, divided into 12 participants in the epidural group and 11 in the ESPB group. Research on 64 patients reported mean ages of  $71.4 \pm 10.1$  in the FIB group and  $69.3 \pm 12$  in the ESPB group, including 20 females in the FIB group and 12 in the ESPB group. A study of 73 patients reported mean ages of 69 years (range: 61-77) in Group A and 71 years (range: 60-82) in Group B, comprising 16 males and 19 females. Research included 888 TKA patients and 756 THA patients of various ages, with no reported gender distribution. Another study examined 16 patients with a mean age range of 65 to 69 years without reporting gender details.

**Table 2- Intervention (type of anesthesia and analgesia), Cardiovascular and other morbidity (myocardial infarction, arrhythmia, and hypotension), Deep venous thrombosis, Pulmonary embolus, Duration of surgery, Length of stay and Mobility**

Study	Intervention (type of anesthesia and analgesia)	Cardiovascular and other morbidity (myocardial infarction, arrhythmia, and hypotension)	Deep venous thrombosis	Pulmonary embolus	Duration of surgery	Length of stay	Mobility



<b>Gola et al.<sup>(7)</sup></b>	Supra-inguinal fascia iliaca compartment block (S-FICB)"	Cardiovascular morbidity included hypertension.	Deep Venous Thrombosis in Hip Replacement	NR	NR	The length of stay for the participants in the study was reported as 5-6 days.	NR
<b>Kuchalik et al.<sup>(8)</sup></b>	Intrathecal morphine and local infiltration analgesia.	Risk of infection	Deep venous thrombosis in Prophylaxis.	Pulmonary embolus, a serious condition, was among the exclusion criteria in the study on postoperative pain management for elective THA.	The duration of surgery for the patients undergoing THA in the study was around 106 minutes for the ITM group and 112 minutes for the LIA group.	The study focused on home readiness as a more accurate endpoint rather than length of stay (LOS) after total hip arthroplasty (THA), with no significant differences found between the groups in terms of LOS (2-6 days)	Mobility was assessed postoperatively in patients by measuring the time to home readiness and attempts to mobilize after surgery.
<b>Pascarella et al.<sup>(9)</sup></b>	PENG block after spinal anesthesia and before incision, injecting ropivacaine 0.375% in iliopsoas muscle plane.	PENG block for THA showed lower pain scores and reduced opioid consumption, indicating lower morbidity.	Deep venous thrombosis is a blood clot forming in a deep vein often seen after hip replacement surgery.	NR	The duration of surgery for the patients undergoing PENG in the study was around 104 minutes for the Control group and	The length of stay for the participants in the study was reported as 2-3 days.	Mobility was assessed regarding range of motion and time first to walk. Patients receiving the PENG block showed a better range of motion and a shorter time to first walk

					107 minutes for the LIA group.		than the control group.
<b>Stevens et al.<sup>(10)</sup></b>	GA and lumbar plexus block with morphine analgesia were intervention s used for THA in the study.	Cardiovascular effects of two regional anesthetic techniques compared by Fanelli et al. for unilateral leg surgery in the study.	Deep venous thrombosis (DVT) was observed as a potential complication of THA and can be mitigated by appropriate management strategies.	NR	The duration of surgery for the patients undergoing plexus in the study was around 130 minutes for the control group and 132 minutes for the control group.	NR	The study mentions that observations such as asymmetric thigh mobility were noted among patients. This observation, along with other factors like epidural blockade and decreased opioid requirements, may have introduced bias among patients and data collectors during the study.
<b>Lennon et al.<sup>(11)</sup></b>	The study used spinal anesthesia intraoperatively and local anesthetic infiltration with oral multimodal analgesia postoperatively.	One patient in the saline group had transient severe bradycardia postoperatively .	NR	NR	The duration of surgery for the patients undergoing Saline in the study was around 62 minutes, while for the ropivacaine, it was 63 minutes.	The length of stay in the study was longer than expected due to local health policies and patient/surgeon expectations.	The study focused on postoperative mobility after hip arthroplasty, with delays attributed to orthostatic intolerance rather than pain.
<b>Townse</b>	The	NR	Deep vein	NR	Case time	The length of	NR

<b>nd et al.</b> (12)	intervention involved lumbar Erector Spinae Plane Block (ESPB) with ropivacaine, spinal anesthesia, and multimodal analgesia.		thrombosis (DVT) risk factors include surgery, immobility, and hypercoagulable states; prevention involves early mobilization and anticoagulation.		(minutes) ESPB group- 115 mins Control group- 118 mins	stay for the participants in the study was reported as 2 days in the ESPB group and 3 days in the control group.	
<b>Hanych et al.</b> <sup>(13)</sup>	Patients received spinal anesthesia with either lumbar erector spinae plane block or epidural analgesia postoperatively.	NR	NR	NR	The duration of surgery ranged from 70 minutes	NR	The study evaluates patient mobility after hip replacement surgery using physiotherapist assessments and the timed-up test. It compares pain management techniques and finds that lumbar erector spinae plane block (ESPB) is comparable to epidural analgesia in terms of mobility outcomes.
<b>Flavian</b>	The	NR	DVT, a	Pulmonary	FIB group-	NR	Motor-sparing

<b>o et al.<sup>(14)</sup></b>	intervention included fascia iliaca block or erector spinae plane block followed by spinal anesthesia for THA.		complication linked to hip surgery, is a risk factor due to immobility, surgery trauma, and altered blood flow, necessitating early detection and prevention measures.	embolus, a serious condition, occurred postoperatively, particularly after hip replacement surgery, requiring prompt medical attention.	80 mins  ESPB group-78mins		techniques, early mobilization, minimizing quadriceps impairment after surgery.
<b>Becchi et al.<sup>(15)</sup></b>	The intervention involved regional anesthesia and opioid-free analgesia using saline infusion or externally fixed catheters without infusion.	Cardiovascular morbidity was monitored during the study, with specific criteria for bradycardia, hypotension, and treatment with ephedrine.	NR	NR	NR	NR	The study mentions that effective pain control after surgeries is crucial for patient ambulation, recovery, and discharge. By utilizing continuous nerve blocks, patients experience reduced pain levels, impacting mobility and aiding in rehabilitation.

<b>Anderse n et al.</b> (16)	Intervention s include intra- operative local anesthetic infiltration, wound catheters for postoperativ e local anesthesia, and systemic analgesia.	NR	Deep venous thrombosis (DVT) was found as a potential complication after TKA and THA surgeries.	NR	The duration of surgery ranged from 1 to 6 hours for various procedures.	Length of stay varied from 2 to 7 days in the included trials, with reasons for differences not described.	Mobility after hip arthroplasty was not improved by periarticular local anesthesia .
<b>Turnbul l et al.</b> (17)	Regional anesthesia (RA) techniques, including continuous peripheral nerve blockade and catheters.	Reduced cardiovascular complications such as myocardial infarction, arrhythmia, and hypotension.	Deep venous thrombosis is decreased by RA and associated with decreased mortality in patients undergoing total knee replacement.	The study highlights the benefits of RA in reducing complicatio ns like deep vein thrombosis, pulmonary embolism, and transfusion requiremen ts, including the risk of pulmonary embolism.	The duration of surgery can vary, but it typically lasts around 2-3 hours.	Length of stay post-TKA is typically reduced by utilizing fast- track protocols, resulting in improved outcomes.	Multimodal pain management, accelerated rehab, cognitive improvement, decreased complications, and cost savings in TKA enhance recovery.

NR: Not reported

## **Intervention (Type of Anaesthesia and Analgesia)**

Supra-inguinal fascia iliaca compartment block (S-FICB) was employed for anesthesia and analgesia.<sup>(7)</sup> Intrathecal morphine and local infiltration analgesia were utilized, with surgery durations of around 106 minutes for the ITM group and 112 minutes for the LIA group.<sup>(8)</sup> A PENG block was used after spinal anesthesia and before incision, injecting ropivacaine 0.375% in the iliopsoas muscle plane, with surgery durations of approximately 104 minutes for the PENG group and 107 minutes for the control group.<sup>(9)</sup> General anesthesia and lumbar plexus block with morphine analgesia were implemented for THA, with surgery durations of around 130 minutes for the plexus group and 132 minutes for the control group.<sup>(10)</sup> The lumbar plexus block combined with morphine analgesia is highly effective for pain management in total hip arthroplasty (THA).<sup>(18)</sup> This technique involves local anesthetic injection near the lumbar plexus, providing comprehensive sensory blockade of the hip. The addition of morphine enhances analgesic efficacy, offering prolonged pain relief. Studies have shown this combination significantly reduces postoperative pain and opioid requirements while maintaining stable hemodynamics.<sup>(19)</sup> Spinal anesthesia was used intraoperatively and local anesthetic infiltration with oral multimodal analgesia postoperatively, with surgery durations of about 62 minutes for the saline group and 63 minutes for the ropivacaine group.<sup>(11)</sup> lumbar erector spinae plane block (ESPB) with ropivacaine, spinal anesthesia, and multimodal analgesia was administered, with case times around 115 minutes for the ESPB group and 118 minutes for the control group.<sup>(12)</sup> This regional anesthesia technique involves injecting ropivacaine into the fascial plane deep into the erector spinal muscle.<sup>(20)</sup> Several studies have shown that the use of ropivacaine in conjunction with erector spinae plane block results in considerable pain alleviation, a reduction in the use of opioids, and a reduction in the risk of cardiovascular and other systemic problems.<sup>(21)</sup> The effectiveness of this block in enhancing postoperative recovery and lowering morbidity makes it a desirable choice for treating pain during the perioperative period or before surgery. Spinal anesthesia was provided postoperatively using either a lumbar erector spinae plane block or epidural analgesia.<sup>(13)</sup> The inclusion of a fascia iliaca block or erector spinae plane block, followed by spinal anesthesia for total hip arthroplasty (THA), resulted in surgery durations of approximately 80 minutes for the fascia iliaca block group and 78 minutes for the erector spinae plane block group.<sup>(14)</sup> Fascia iliaca block entails administering an injection close to the fascia iliaca compartment to block nerves that feed the hip. The erector spine plane block technique includes administering an injection close to the erector spinal muscles, which provides extensive pain relief during hip surgery. To improve pain management, decrease the amount of opioids that are required for the whole body, and perhaps reduce the risk of cardiovascular problems, these procedures are often coupled with spinal anesthesia.<sup>(22)</sup> RA and opioid-free analgesia were used with saline infusion or externally fixed catheters without infusion, with surgery durations starting from 70 minutes.<sup>(15)</sup> Intraoperative local anaesthetic infiltration, wound catheters for postoperative local anaesthesia, and systemic analgesia were included, with surgery durations varying from 1 to 6 hours for various procedures.<sup>(16)</sup> RA techniques, including continuous peripheral nerve blockade and catheters, were employed, with typical surgery durations of around 2-3 hours.<sup>(17)</sup> Certain surgical procedures have the shortest durations, indicating high efficiency. Furthermore, treatments using multimodal approaches can be regarded as superior in delivering more complete pain management.<sup>(12)</sup>

## Comorbidity

Cardiovascular morbidity, including hypertension, has been reported. The PENG block for THA showed lower pain scores and reduced opioid consumption, indicating lower morbidity. A comparison of the cardiovascular effects of two regional anaesthetic techniques for unilateral leg surgery was conducted. One patient in the saline group experienced transient severe bradycardia postoperatively. Some studies did not report specific cardiovascular morbidities, while another study monitored cardiovascular morbidity with criteria for bradycardia, hypotension, and treatment with ephedrine. Reduced cardiovascular complications such as myocardial infarction, arrhythmia, and hypotension were observed. Deep venous thrombosis (DVT) was a noted complication across several studies. DVT, often seen after hip replacement surgery, was discussed as a blood clot complication, mitigated by appropriate management strategies. Risk factors such as immobility and hypercoagulability were identified, with prevention strategies involving early mobilization and anticoagulation. The necessity of vigilant monitoring for DVT postoperatively, especially after hip surgery, was highlighted. The importance of early detection and prevention measures to reduce DVT risk was emphasized. Pulmonary embolus (PE) was another serious postoperative complication. Pulmonary embolism (PE) is a significant complication following hip replacement surgery. It occurs when a blood clot travels to the lungs, obstructing blood flow. Postoperative PE is associated with high morbidity and mortality rates.<sup>(23)</sup> Preventive measures include anticoagulation therapy, early mobilization, and mechanical prophylaxis like compression devices. Recent advancements emphasize the importance of individualized risk assessment to optimize prophylaxis.<sup>(24,25)</sup> Enhanced recovery protocols and minimally invasive surgical techniques also reduce PE incidence. In their study, PE risk assessment was included, while PE was noted among the exclusion criteria in a study on postoperative pain management for elective THA. PE was reported as a serious condition that could occur postoperatively, particularly after hip replacement surgery, requiring prompt medical attention. The studies highlighted the benefits of RA in reducing complications like DVT and PE, which could lead to fatal outcomes such as respiratory compromise. The strategies described seem to be especially beneficial owing to their direct influence on lowering pain and opiate usage, which in turn leads to decreased total morbidity. However, the thorough care of cardiovascular problems and deep vein thrombosis (DVT) is especially noteworthy. It makes them great contenders for the best overall strategy in terms of safety and effectiveness. Deep vein thrombosis (DVT) is a significant concern following hip replacement surgery. This condition involves the formation of blood clots in the deep veins, typically in the legs. Postoperative immobility and surgical trauma increase the risk.<sup>(26)</sup> Prophylactic measures, such as anticoagulant medications and mechanical compression devices, prevent DVT.<sup>(27)</sup> Early mobilization and physical therapy are also essential components of patient care to reduce the likelihood of clot formation. Vigilant monitoring for symptoms like swelling, pain, and redness in the legs is crucial for early detection and management of DVT.

**Table 3: Pain (pain scores), Opioid-related adverse effects (nausea, vomiting, pruritis, sedation, urinary retention, and respiratory depression), Opioid consumption, cognitive defects, and Rehabilitation (range of motion and ambulation)**

<b>Study</b>	<b>pain (pain scores)</b>	<b>Opioid-related adverse effects (nausea, vomiting, pruritis, sedation, urinary retention, and respiratory depression)</b>	<b>Opioid consumption</b>	<b>cognitive defects</b>	<b>rehabilitation (range of motion and ambulation)</b>
<b>Gola et al.<sup>(7)</sup></b>	Postoperative pain management after hip surgery using fascia iliaca compartment block to reduce opioid consumption and improved analgesia efficacy.	Postoperative nausea and vomiting Bradycardia Hypotension	Opioid consumption was higher in controls, with 61.4 mg.	NR	Rehabilitation outcomes, including range of motion and ambulation, were significantly better in the FICB group, with lower pain scores during rehabilitation on days 1 and 2 postoperatively.
<b>Kuchalik et al.<sup>(8)</sup></b>	Pain scores were assessed at various time points, showing that patients in the ITM group had lower pain scores at rest at 8 hours post-surgery, while those in the LIA group had lower pain intensity	pruritus, urinary retention	Opioid consumption was compared between intrathecal morphine and local infiltration analgesia groups, showing	NR	Rehabilitation, including physiotherapy post-surgery



	during mobilization at 24-48 hours		minimal differences in dosage.		
<b>Pascarella et al.<sup>(9)</sup></b>	Pain was assessed using a 0-10 NRS scale, with patients indicating perceived pain levels at various postoperative time points.	Opioid-related adverse effects include nausea, vomiting, and dizziness; PENG blocks reduced opioid consumption and risk of adverse events.	In the study, patients who received the PENG block had significantly lower opioid consumption compared to the control group.	NR	Rehabilitation involved ambulation with a walker after 10 hours postoperatively, aiding recovery and functionality for hip arthroplasty patients.
<b>Stevens, et al.<sup>(10)</sup></b>	Pain scores were significantly reduced in the plexus group with lower morphine consumption; 0 pain was reported in some patients.	Opioid-related adverse effects included nausea, vomiting, pruritis, sedation, urinary retention, and respiratory depression in postoperative patients.	NR	Cognitive defects were present postoperatively in two patients, leading to their exclusion from data analysis in the study.	Rehabilitation after hip surgery involves improving the range of motion and ambulation to regain function and mobility efficiently.
<b>Lennon, et al.<sup>(11)</sup></b>	Pain scores were assessed using a numeric rating scale with a 2-point difference considered clinically significant. The study evaluates pain using the Numeric Rating Scale (NRS) scores ranging from 0	The study reported negligible opioid-related adverse effects, including nausea, vomiting, pruritis, sedation,	In the study, opioid use was not the primary outcome measure; Quality of Recovery-15 was considered more important.	NR	Both groups had similar rates of successful mobilization, with orthostatic intolerance being the main limiting factor in rehabilitation.

	to 10. It assesses pain at rest and with movement at different time points post-surgery, such as 6 hours and 24 hours. The study also considers an appreciable analgesic benefit as a 2-point difference on the NRS pain scale.	urinary retention, and respiratory depression.			
<b>Townsend et al.<sup>(12)</sup></b>	Pain scores were assessed using the numerical rating scale (NRS), and there was no significant difference between the groups at 24 hours.	Opioid-related adverse effects include respiratory depression, constipation, sedation, nausea, vomiting, and potential addiction risks.	Opioid consumption in the study was reported in oral morphine equivalents.	Inconsistent sensory loss in L1-L3 dermatomes observed post-surgery.	Rehabilitation after hip arthroplasty includes a range of motion and ambulation.
<b>Hanychet al.<sup>(13)</sup></b>	Pain scores were measured using the Visual Analog Scale (VAS) at different times. The study compares pain management techniques and mobility outcomes after hip replacement surgery, finding that lumbar erector spinae plane block (ESPB) is comparable to epidural	NR	Total oxycodone consumption with PCA during the first 24 hours.	NR	Rehabilitation post-hip replacement includes measuring muscle strength, pain, and mobility through motion and ambulation assessments.

	analgesia.				
<b>Flaviano et al.</b> <sup>(14)</sup>	Pain scores were assessed using NRS, with severe pain defined as NRS > 5. The study compares femoral nerve block and erector spinae plane block techniques for pain management after THA, finding no significant differences and emphasizing the importance of early pain management.	Opioid-related adverse effects included nausea, vomiting,	Opioid consumption at different time points was compared between the two blocks.	Cognitive defects were not mentioned in the study regarding morphine consumption and postoperative pain assessment.	Rehabilitation after THA includes a range of motion exercises and early ambulation for optimal recovery and functional outcomes.
<b>Becchi et al.</b> <sup>(15)</sup>	Pain scores in Group A were consistently low, whereas Group B experienced higher pain scores, especially during physiotherapy.	In Group A, where opioid-free continuous psoas compartment block was used, less rescue analgesia was needed, and less nausea and vomiting were observed compared to Group B, which received intravenous morphine/ketorolac infusion.	The study reported opioid consumption was minimized by using opioid-free analgesia techniques post-THA.	Cognitive defects, including hepatic or renal insufficiency and dementia, were excluded from the study criteria.	Rehabilitation includes early mobilization, focusing on a range of motion and ambulation for optimal recovery outcomes.
<b>Andersen et al.</b> <sup>(16)</sup>	Pain scores were measured using a	NR	Opioid consumption was	NR	Rehabilitation after TKA and THA

	visual analog scale for pain at rest and with mobilization in the studies. The study compares local infiltration analgesia (LIA) with other pain relief techniques in hip and knee arthroplasty. LIA reduces pain scores and opioid requirements, providing similar or improved analgesia in the early postoperative period. It highlights the potential benefits of LIA in managing postoperative pain effectively.		decreased at 7 and 12 hours post-surgery with intraoperative periarticular injection in THA patients.		included a range of motion and ambulation assessments in the document.
<b>Turnbull et al.</b> <sup>(17)</sup>	The study emphasizes the significance of multimodal analgesia in enhancing postoperative pain control and reducing systemic narcotic consumption, utilizing strategies like peripheral nerve blockade and per articular injection.	Opioid-related adverse effects include nausea, vomiting, pruritus, sedation, and respiratory depression. Opioid consumption affects cognitive function, rehabilitation, and ambulation.	Opioid consumption post-TKA is reduced by pregabalin but not gabapentin, according to a study.	The study mentions a decrease in postoperative cognitive delirium with fast-tracked patient populations and a more rapid time to discharge. It also discusses the potential cognitive benefits of RA techniques, such as reducing	Rehabilitation includes a range of motion exercises and ambulation training.

				the risk of cognitive defects compared to GA.	
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**Mobility and rehabilitation**

Mobility and rehabilitation outcomes were assessed in various studies. One study evaluated mobility by measuring time to home readiness and attempts to mobilize after surgery, reporting significantly better rehabilitation outcomes, including a range of motion and ambulation, in the FICB group with lower pain scores during rehabilitation on days 1 and 2 postoperatively. Another study assessed mobility through range of motion testing and time to first walk, finding that patients who received the PENG block showed better outcomes, with rehabilitation including physiotherapy post-surgery. Asymmetric thigh mobility is a common issue among patients undergoing hip replacement surgery. This condition can lead to discrepancies in leg length and altered gait patterns, impacting recovery and overall mobility. Studies suggest that targeted physical therapy and post-operative exercises are crucial in addressing these mobility differences and improving patient outcomes. Recent advancements in surgical techniques and rehabilitation protocols also contribute to better management of this condition.<sup>(28)</sup> Observations such as asymmetric thigh mobility among patients, along with other factors like epidural blockade and decreased opioid requirements, could have introduced bias. Rehabilitation involved ambulation with a walker after 10 hours postoperatively, aiding recovery and functionality for hip arthroplasty patients. Postoperative mobility after hip arthroplasty faced delays attributed to orthostatic intolerance rather than pain, emphasizing the importance of improving range of motion and ambulation for efficient recovery. Mobility was assessed using the Timed test, with similar rates of successful mobilization in both groups, and orthostatic intolerance being the main limiting factor. Rehabilitation post-hip replacement included measuring muscle strength, pain, and mobility through motion and ambulation assessments. Rehabilitation post-hip replacement generally focuses on restoring mobility and strength, reducing pain, and improving overall function. It includes physical therapy exercises, gait training, and lifestyle modifications.<sup>(29)</sup> Early mobilization and personalized rehab plans enhance recovery outcomes. Typically, patients begin therapy within a day post-surgery, progressing from assisted walking to more advanced exercises over weeks. Adherence to rehab protocols is crucial for optimal recovery and long-term joint health. A comparison of pain management techniques found that lumbar erector spinae plane block (ESPB) was comparable to epidural analgesia in terms of mobility outcomes. The study discussed motor-sparing techniques, early mobilization, and minimizing quadriceps impairment after surgery. Rehabilitation after THA included a range of motion exercises and early ambulation for optimal recovery and functional outcomes. Another study highlighted the crucial role of effective pain control in patient ambulation, recovery, and discharge, with continuous nerve blocks aiding in the rehabilitation process. Emphasis on early mobilization with a focus on a range of motion and ambulation was found to be essential for optimal recovery outcomes, and rehabilitation after TKA and THA included these assessments. Effective pain control was noted to be crucial for patient ambulation, recovery, and discharge, with continuous nerve blocks aiding in the rehabilitation process, which included a range of motion exercises and ambulation training. Efficient pain management and early mobilization are critical in hip replacement recovery. Utilizing multimodal analgesia, including regional nerve blocks and non-opioid medications, minimizes pain while reducing opioid dependence.<sup>(30)</sup> Early mobilization protocols, incorporating

physical therapy and ambulation, accelerate functional recovery and decrease postoperative complications. These approaches enhance patient satisfaction, shorten hospital stays, and improve long-term outcomes, emphasizing the importance of comprehensive perioperative care in hip replacement procedures. The combination of efficient pain management and early mobilization approaches emerged as the most successful strategy in this review's research on mobility and rehabilitation outcomes. Several additional studies have consistently emphasized the significance of early mobility and efficient pain management, with continual nerve blocks assisting in the healing process and ambulation and discharge. In light of this, it would seem that combining these modalities is the most successful and optimal strategy for postoperative mobility and rehabilitation.

## Pain Management

Postoperative pain management and opioid-related adverse effects were key focuses across the studies. Various techniques were employed to manage postoperative pain, including the fascia iliaca compartment block, which reduced opioid consumption and improved analgesia efficacy, and intrathecal morphine (ITM), which resulted in lower pain scores at rest at 8 hours. Local infiltration analgesia (LIA) was shown to lower pain intensity during mobilization at 24-48 hours. Pain assessments using the 0-10 Numeric Rating Scale (NRS) revealed significantly lower scores in the PENG block group, with some patients reporting no pain and lower morphine consumption. Studies measuring pain using NRS and the Visual Analog Scale (VAS) emphasized the importance of early pain management and noted negligible opioid-related adverse effects in some cases. The benefits of local infiltration analgesia (LIA) and multimodal analgesia in reducing systemic narcotic consumption were highlighted. Opioid-related adverse effects, such as nausea, vomiting, and respiratory depression, were consistently reported, with efforts made to minimize opioid use and improve pain management strategies. Among the procedures explored, the fascia iliaca compartment block, ITM, and the PENG block were particularly effective. Combining these different approaches appears to be the most effective and efficient method for postoperative pain treatment.

**Table 4: Outcome of the study, Limitations, Features of the study, Recommendations and Critical influencing factors**

Study	The outcome of the study	Limitations	Features of the study	Recommendations	Critical influencing factors
Gola et al. (7)	pain severity, analgesic consumption were studied	Small sample, local factors, short follow-up	Small sample size, very few limitations, effective analgesia	Recommendations for Effective Analgesia:  Use supra-inguinal fascia iliaca compartment	Pain management methods

				block (S-FICB) Reduce opioid use Shorten hospital stay Ensure high patient satisfaction	
<b>Kuchalik et al.<sup>(8)</sup></b>	Lower rescue analgesic consumption and fewer side effects	The exact placement of the catheter in the hip joint remains unclear and unexplored.	It assessed morphine consumption, pain scores, analgesic use, and side effects. The randomized, double-masked design and specific patient population provided robust findings on postoperative pain management efficacy and safety.	LIA is a good alternative to spinal morphine for postoperative pain management in patients undergoing total hip replacement.	Patient motivation, time of day for tests, absence of relatives at home, distance to medical facility, day of surgery.
<b>Pascarella et al.<sup>(9)</sup></b>	The study showed lower pain scores and reduced opioid consumption in patients receiving PENG block after hip arthroplasty.	Limitations include potential biases, small sample size, and lack of detailed pain assessment methods.	The study compared PENG block and control groups to ensure unbiased results. The randomized design enhanced reliability, highlighting potential benefits in postoperative	Perform PENG block for THA with 20ml of ropivacaine 0.375%, following Girón-Arango's technique for analgesia.	Patient randomization, PENG block technique, opioid consumption, pain scores, block performed before incision, ropivacaine injection, and experienced anesthetists.

			<p>pain management and reduced opioid use. The research assessed crucial outcomes, including pain scores and opioid consumption.</p>		
<p><b>Stevens et al.<sup>(10)</sup></b></p>	<p>The study showed reduced isoflurane use, decreased blood loss, lower pain scores, and less morphine needed in patients with plexus block.</p>	<p>Limitations of the study include potential bias due to observations affecting blinding and the need for further research.</p>	<p>The study on THA found that using a Lumbar Plexus block reduced opioid administration, reduced blood loss, and improved pain management compared to a control group.</p>	<p>The study suggests that posterior LP block improves anesthetic and analgesic management in THA but recommends further research to extend the benefits postoperatively and explore reduced bleeding.</p>	<p>Preoperative characteristics, isoflurane administration, mean arterial pressure, blood loss, supplemental fentanyl use, and duration of surgery.</p>
<p><b>Lennon et al.<sup>(11)</sup></b></p>	<p>Patients in both groups had similar pain levels and quality of recovery after surgery with spinal anesthesia and ultrasound-guided erector</p>	<p>Limitations of the study included the lack of dermatomal assessment for block efficacy and potential differences in opioid use between groups.</p>	<p>The study, a blinded, placebo-controlled trial, evaluates the erector spinae plane block (ESPB) for hip arthroplasty. It follows</p>	<p>Further studies are needed to assess ESPB benefits in opioid-tolerant or complex hip surgery patients for improved outcomes.</p>	<p>Orthostatic intolerance and local analgesic infiltration may have influenced outcomes in the study of ESPB for hip arthroplasty.</p>



	spinae plane block.		international perioperative standards with a robust methodology. Results indicate limited benefits of adding ESPB to existing pain management. Acknowledged limitations include the small-scale nature of the trial affecting generalizability.		
<b>Townsend et al.</b> <sup>(12)</sup>	Opioid consumption, pain scores, and adverse events were assessed.	Blinding, inconsistent sensory loss, premature termination.	Patient recruitment, randomization, blinding, data curation, and investigation.	Larger randomized trials are needed to evaluate lumbar ESPB benefits on opioid requirements after hip arthroplasty and explore longer-acting local anesthetics.	Critical influencing factors include patient age, surgical procedure type, anesthesia method, medication allergies, and previous opioid use.
<b>Hanych et al.</b> <sup>(13)</sup>	Total oxycodone consumption, PCA demands, pain levels on VAS, muscle strength, timed-up test, satisfaction, and	The study didn't directly compare lumbar erector spinae plane block to epidural analgesia, impacting the	The study measured oxycodone consumption, pain levels, muscle strength, mobility, vital	Provide adequate postoperative pain control with oxycodone PCA, assess muscle strength using	Critical influencing factors: pain control, quality of recovery, muscle strength, Timed Up and test, and heart rate changes.

	quality of recovery were assessed.	generalization of results.	signs, and patient satisfaction post-hip replacement. Statistical analysis included a t-test, Mann-Whitney U test, and various measurements.	the Lovett scale, and monitor mobility using TUG.	
<b>Flaviano et al.<sup>(14)</sup></b>	No significant difference in morphine consumption, pain scores, or better sensory blocks with FIB compared to ESPB.	The study did not assess long-term outcomes beyond one-year post-surgery for chronic postsurgical pain.	Baseline characteristics, sensory block assessments, postoperative outcomes, and chronic pain assessment.	Consider using FIB for more reliable sensory blocks, monitor for chronic postsurgical pain, and expand the sample size for generalizability.	Sensory testing with FIB, morphine consumption, motor block intensity, and chronic postsurgical pain assessment.
<b>Becchi et al.<sup>(15)</sup></b>	Patients in Group A had significantly lower pain scores at rest and during physiotherapy compared to Group B.	Small sample size (37 and 36 patients) Non-compliance with rehabilitation protocol Lack of details on specific outcomes	Randomized trial with successful spinal anesthesia, cPCB analgesia, functional lumbar plexus catheters, and matched patient characteristics.	Recommendations for opioid-free analgesia after THA include spinal anesthesia, cPCB analgesia, and continuous infusion with catheters.	Successful analgesia, functional catheters, patient compliance, and matched characteristics influenced pain scores and study outcomes.
<b>Andersen et al.<sup>(16)</sup></b>	Analgesic efficacy of peri-articular injection in TKA and THA, postoperative opioid consumption, and	The lack of direct comparison and meta-analysis of study outcome measures (pain, opioid	Randomized controlled trials with 888 TKA and 756 THA patients assessing analgesic	Optimize LIA use based on procedure-specific evidence.	Procedure type, multimodal analgesia, opioid-sparing, length of stay, patient outcomes, and future research priorities.

	length of hospital stay.	requirements).	efficacy and opioid consumption.		
<b>Turnbull et al.<sup>(17)</sup></b>	The study highlights the benefits of fast-track patient recovery after orthopedic procedures, including reduced LOS, reduced analgesic intake, improved cognitive delirium, faster discharge, and reduced readmissions compared to standard rehabilitation protocols.	The limitation of the study was the need for a more detailed analysis of specific anesthesia techniques during total knee replacement.	The study evaluated the analgesic effects of perioperative gabapentin in TKA through randomized controlled trials.	The study suggests utilizing gabapentin for postoperative pain management in TKA based on various studies.	Preoperative patient education, multimodal analgesic regimens, peripheral nerve block, postoperative interventions, and accelerated rehabilitation maximize outcomes.

## Features of the study

The studies in Table 4 focus on various aspects of pain management and outcomes in different surgical procedures. Gola et al.<sup>(7)</sup> studied pain severity and analgesic consumption. Kuchalik et al.<sup>(8)</sup> found lower rescue analgesic consumption and fewer side effects. Recent studies indicate that advanced multimodal pain management strategies in hip replacement surgery lead to lower rescue analgesic consumption and fewer side effects.<sup>(31)</sup> Techniques, such as regional anesthesia, perioperative NSAIDs, acetaminophen, and minimally invasive surgical techniques, enhance recovery.<sup>(32)</sup> These methods not only reduce opioid use but also minimize common adverse effects like nausea and constipation, improving patient outcomes and satisfaction. Pascarella et al.,<sup>(9)</sup> reported lower pain scores and reduced opioid consumption with PENG block after hip arthroplasty. The Pericapsular Nerve Group (PENG) block has been shown to lower pain scores and reduce opioid consumption in patients undergoing hip arthroplasty.<sup>(33)</sup> By effectively targeting the sensory nerves around the hip, the PENG block provides significant pain relief, reducing the need for opioids postoperatively. This technique not only enhances patient

comfort but also minimizes the risk of opioid-related side effects and dependence, contributing to a faster recovery and improved overall outcomes. Reduced isoflurane use, decreased blood loss, and lower pain scores were observed with plexus block. In hip replacement surgery, a plexus block has been shown to reduce isoflurane usage, decrease intraoperative blood loss, and lower postoperative pain scores.<sup>(34)</sup> This regional anaesthesia technique enhances patient outcomes by providing targeted pain relief and minimizing the need for general anaesthesia, which can lead to fewer side effects and faster recovery times. Lennon et al.,<sup>(11)</sup> found similar pain levels and quality of recovery with different anaesthesia methods. Recent research comparing anaesthesia methods in hip replacement surgery unveils varying pain levels and recovery qualities. One study contrasts general anaesthesia with regional techniques, indicating superior pain control and quicker rehabilitation with the latter.<sup>(35)</sup> Another investigation emphasizes the impact of anaesthesia types on postoperative discomfort and functional outcomes, highlighting the advantage of regional anaesthesia in optimizing recovery. The study assessed opioid consumption, pain scores, and adverse events. To enhance patient care, recent investigations have examined opioid consumption, pain scores, and adverse events related to hip replacement surgery.<sup>(36)</sup> In the postoperative period, alternative pain management approaches, including nerve blocks and multimodal analgesia, have surfaced as viable alternatives to opioids. Furthermore, innovative pain management strategies customized to specific patient profiles have demonstrated the potential to enhance results and reduce untoward occurrences. The results of this study emphasize the criticality of optimizing pain management protocols to promote recovery and reduce the potential hazards linked to opioid dependence and complications. Various outcomes were reported, including oxycodone consumption, pain levels, and satisfaction. Outcomes of hip replacement surgery often include assessing oxycodone consumption, pain levels, and patient satisfaction.<sup>(37)</sup> Opioid-sparing protocols significantly reduce oxycodone usage while maintaining equivalent pain control compared to traditional opioid regimens. Patients on these protocols consume fewer opioids during and after hospitalization, achieving similar pain relief and functional outcomes over 90 days. Patient satisfaction is largely influenced by effective pain management and the alignment of preoperative expectations with actual surgical outcomes. Using multimodal analgesia and minimizing opioid use enhances recovery and satisfaction while reducing opioid-related side effects, leading to better overall outcomes in hip replacement surgeries.<sup>(38)</sup> Several studies have found no significant differences between groups in pain scores and sensory blocks. Research comparing various anesthesia techniques and postoperative pain management protocols has found that outcomes are generally similar regardless of the specific approach used.<sup>(39)</sup> Both regional and general anesthesia, as well as different analgesic strategies, provide comparable pain relief and sensory block effectiveness.<sup>(40)</sup> These findings suggest that the choice of anaesthetic technique can be based on other factors, such as patient preference or medical history, without compromising pain management outcomes. Patients undergoing hip replacement surgery who received personalized pain management strategies experienced significantly lower pain scores compared to those who received standard care. The tailored approaches included multimodal analgesia and patient-specific interventions, leading to improved postoperative outcomes and patient satisfaction.<sup>(41)</sup> These findings highlight the importance of customized pain management in enhancing recovery and reducing discomfort in hip replacement patients. Becchi et al.,<sup>(15)</sup> evaluated analgesic efficacy and length of hospital stay. Effective analgesia is crucial for postoperative recovery and reducing hospital stay in hip replacement surgery.<sup>(42)</sup> Recent studies demonstrate that optimized analgesic protocols, including multimodal approaches with opioid-sparing techniques like regional anesthesia and non-opioid medications, significantly improve pain management and shorten hospital stays. Such findings underscore the importance of personalized pain management strategies in enhancing patient outcomes

and facilitating early mobilization and rehabilitation following hip replacement surgery.<sup>(43)</sup> Critical influencing factors included patient characteristics, anesthesia methods, and postoperative care protocols. These studies contribute valuable insights into optimizing pain management and patient outcomes in surgical settings.

## **CONCLUSION**

The study underscores the critical role of tailored analgesic techniques in optimizing postoperative outcomes for patients undergoing THA and TKA. Techniques such as supra-inguinal fascia iliaca compartment block (S-FICB), intrathecal morphine (ITM), local infiltration analgesia (LIA), pericapsular nerve group (PENG) block, lumbar plexus block, and erector spinae plane block (ESPB) significantly reduce pain scores and opioid consumption. These interventions contribute to improved mobility and rehabilitation outcomes. Despite their effectiveness, each technique carries specific risks and limitations, necessitating careful consideration in clinical practice. Effective pain management strategies enhance patient comfort, reduce hospital stay durations, and improve overall satisfaction. However, the evidence from randomized controlled trials (RCTs) did not conclusively show that the type of anesthesia impacts mortality, cardiovascular issues, or the incidence of DVT and pulmonary embolism (PE) with thromboprophylaxis. Blood loss may be reduced with RA, but the duration of surgery showed no significant difference between RA and GA. While regional analgesia was more effective in reducing postoperative pain, morphine use, and nausea and vomiting compared to systemic analgesia, hospital stay length, and rehabilitation outcomes were not significantly influenced by RA or analgesia methods. Future research should focus on larger sample sizes and longer follow-up periods to validate these findings and refine pain management protocols for orthopedic surgeries.

## Author's Contribution:

**SC, AB**, - Carried out the experiment and collected the data and analysed the data; **MAK**- Conceived and presented the idea; **BKK** -developed the theory and computations verified the analytical methods; and **PK**-encouraged and supervised the findings of this work, and guided the entire work; **VM**- Drafted the manuscript and aided in designing and writing the manuscript.

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## Conflict of Interest

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